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ABSTRACT

The objective of this pilot study was to directly compare operationalizations of Piagetian and behavioristic learning theories in terms of acquired skills and transferability of knowledge acquired. It was hypothesized that, in a population of kindergarten children, (1) Piagetian and behavioristic methods would be equally effective in teaching addition, (2) the Piagetian method would be more effective than the behavioristic method with regard to transfer or generalization of mathematical concepts from addition to subtraction tasks, and (3) neither the Piagetian nor the behavioristic method of teaching would adversely affect the self-concepts of participating children. Subjects were 35 children of 5 to 6 1/2 years of age who had not yet entered the first grade and who had no previous training in addition or subtraction. Assignment to Piagetian, behavioristic, or control groups was by random selection, stratified by general academic ability, by kindergarten versus non-kindergarten attendance, and by which of two community schools the child attended. Each of the two experimental groups met with their respective teachers 3 days a week for 8 weeks for 45-minute Piagetian or behavioristic instructional sessions. Control group members continued their usual school or home activities. Results are discussed. (RH)

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Comparison of Learning Theories

Operationalized as Teaching Methods: Piagetian vs Behavioristic

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Running head: Comparison of Learning Theories

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Abstract

This pilot study operationalized and experimentally compared Piagetian learning theory and behavioristic learning theory. .Thirteen boys and ten girls at age 5 to 6½ years were exposed to training in mathematics, specifically addition. Neither group scored differently from the quasi-control group of twelve 5 to 6½ year old children on learned ability to add; however, the behavioristic group was better able to generalize its knowledge of mathematical concepts to subtraction tasks. Neither group demonstrated low self concept after the treatment. The study indicated a direction for future experimental studies.

Comparison of Learning Theories

Operationalized as Teaching Methods: Piagetian vs Behavioristic

One of the most controversial issues in education today is the relative effectiveness of non-directive, low-structure education through experience (Piagetian methods) as compared with direct-instruction, high-structure, repetitious-rote education through reinforcement (behavioristic methods). This issue has assumed an important role not only in learning theories but also in education programs throughout academia with direct and long lasting effect on the world's students.

Rhine's (1981) evaluation of the Follow Through program (the continuation of the Head Start Program) compares the Direct Instruction Model with four other models, including a Piagetian model (High Scope Cognitively Oriented Curriculum Model). The results of the Follow Through evaluations suggest that the Direct Instruction Model produces the greatest education gains in comparison with the other models. The ABT IV Report (Rhine, 1981) also indicates the Direct Instruction Model as ranking at or near the top of most of the measures used in that national evaluation. However, a recent study of these two models in comparable New York City schools, shows the two educational models as scoring very similarily (Walker, et al, 1980).

Becher's (1980) study demonstrates an opposing opinion: teaching models using indirect methods were more effective in facilitating mathematical achievement in young children than were teaching methods using direct

instruction and drill. Scandura (1967), and Maccoby and Zellner (1970), also support the Piagetian argument by suggesting that discovery learning produces knowledge that is more susceptible to transfer than knowledge learned by rote.

A third approach to this issue is to deny that the orientations are opposite. Kamii (1979) holds that the behavioristic method is merely a part of the encompassing Piagetian whole, and therefore may not be set in juxtaposition to it. Holliman (1980) and Becker, Engelmann & Thomas (1975) refute this assumption with a clear statement of the diversity of goals inherent in each approach. Piaget's theory deals with cognitive development, the processes of thinking, and internal mental operations; while behaviorists make no such claim. Behaviorists' goal is to shape behavior and increase or decrease its frequency, and therefore their focus is on action.

The experiment by Becher (1980) is one of very few attempts to empirically compare operationalizations of these two teaching models in an experimental setting. The acute need for extensive research in this area is ably described by Kuhn (1979).

The objective of the present pilot study is to directly compare operationalizations of Piagetian learning theory and behavioristic learning theory, in terms of acquired skills and transferability of the acquired knowledge, using an experimental laboratory design. It is acknowledged that the Engelmann-Carnine Model is only one technique of several whereby teachers could apply behavioristic techniques. It is possible that other behavioris-

tically oriented techniques may overlap much more extensively with the Piagetian approach. However, in order to compare the two approaches, the Engelmann-Carnine Model was used because it is the most clearly operationalized and documented. The lack of a comparable set of distinct guidelines from which the Piagetian approach may be operationalized necessitated that the experimenters compose such a set, based on the major theoretical and research studies, in order to form a basis for future studies.

Kuhn (1979), in documenting a number of problems in operationalizing Piagetian teaching methods in the past, has also pointed out the need to concisely operationalize Piagetian methods of teaching/learning. There is not a set of teaching practices that makes up a Piagetian approach to teaching (Wadsworth, 1978), and therefore the present study emphasizes the explicit definition and operationalization of the two learning theories/teaching methods.

Operationalization of the Piagetian Theory of Learning

The definition and operationalization of the Piagetian theory of learning in this project is: 1) Building cognitive structures in the mind of the child through the process of constructivism - where the child relates to a rich environment within a certain framework and according to certain rules, and develops knowledge by actively modifying what he/she already knows. The focus is not on discovery, but invention - working freely within a certain framework, according to certain givens. The emphasis in teaching the children to add is to give them opportunities to comprehend what numbers and com-

putations mean. This is done by giving the child opportunities to add objects in their immediate environment. (Maccoby & Zellner, 1970; Kamii, 1973; Lavatelli, 1970; Becker, et al, 1975; Kamii & DeVries, 1978; and Kuhn, 1979). 2) Learning comes with abstraction from actions performed on objects and not from the objects themselves. The child must be actively and mentally engaged with material objects. Exploration and manipulation of concrete materials are needed to stimulate mental activity. Each individual child constructs reality by manipulating objects with the senses and the mind. In teaching number, use blocks, flannel boards, groupings of children, chalkboards, flash cards for problems, and stage appropriate games. Each lesson is presented as a game. (Becher, 1980; Schminke, Maertens & Arnold, 1978; Scandura, 1976; Kuhn, 1979; Weikart, Hohmann & Rhine, 1981; Becker, et al, 1975; Lavatelli, 1970; and Wadsowrth, 1978). 3) The environment is under the control of the child. The emphasis is on child initiation in the learning process, and the motivation to learn and understand lies within the child (intrinsic motivation). The child should come to a task spontaneously for that task to be of optimum value. The teacher's teaching is based on the child's thinking and feelings in each situation, and therefore is relatively unstructured and non-directive. This can be done by confronting the child with novel and interesting situations, encouraging the child to come up with problems of interest to them, encouraging the child to think in her/his own way and to put things into relationships in their way, setting up the classroom to permit the child

to develop and carry out spontaneous interests, and encouraging the child to use mathematical skills in life-like problem situations - used to complete their projects and activities. (Maccoby & Zellner, 1970; Sund, 1976; Wadsworth, 1978; Gaudia, 1974; Hammerman & Morse, 1972; Kamii & DeVries, 1978; and Weikart, et al, 1981). 4) The teacher is to help the child construct her/his understanding of relevant concepts. The teacher acts as a catalyst, stimulating processes that take place naturally over a long period of time. This is to be done by: i) exploring each child's performance, making inferences about structure, and deciding what to teach next (Becker, et al, 1975; Gates, 1978; Kuhn, 1979; and Lavatelli, 1970). ii) Asking appropriate questions at the right time. The right question is in harmony with what the child is thinking about at the moment. The right time, allows him enough time to integrate and consolidate the new information (Kamii & Derman, 1971). These questions should be probes that introduce contradictions or disequilibrium (Becker et al, 1975). iii) asking more questions than giving answers, especially divergent questions. Ask open ended questions to encourage the child to learn how to examine and critique their own thinking (Sund, 1976; and Weikart, et al, 1981). iv) not directly correcting the child's error in reasoning. Ask questions and provide experiences so the child can correct her/his own mistakes (Sund, 1976). 5) The structure and freedom in the child's learning situation must always be kept in balance. The teacher imposes structure

through rules that are set forth and materials that are placed in the environment. (Wadsworth, 1978; Gates, 1978; Kuhn, 1979; and Lavatelli, 1970). 6) In teaching young children, the natural developmental sequences that Piaget described must be taken into account. Both logical and physical knowledge must be structured slowly, beginning at the sensorimotor level and integrating all the intuitive concepts that are necessary for attaining later cognitive abilities. The teacher focuses on the development of underlying cognitive processes that will eventually enable the child to construct his own rules. The teacher also provides activities that are developmentally appropriate, so as to challenge the child's thinking. Within these provided activities, the child is to work at his own level, rate and personal style. (Kamii & Derman, 1971; Hammerman & Morse, 1972; and Engelmann, 1971). Some of the important sequences to be considered are: i) before the child can deal meaningfully with numbers and computations, he/she must comprehend what numbers and computations mean (Wadsworth, 1978). ii) written numbers and written computation can take place meaningfully only after children have come to understand what signs are (Wadsworth, 1978). iii) the child should have a comprehension of mathematical concepts before he is encouraged to deal symbolically with mathematical concepts (that is, use numbers). (Wadsworth, 1978). iv) the child needs to see addition and subtraction as joining and separating actions, before he/she can describe them orally and use action in sentence form. (Schminke, et al, 1978).

7) Interaction with other children facilitates knowledge and learning. If disagreements arise, the group is to be encouraged to come to their own solution. The best avenue to interaction is through group games which encourage physical actions incorporating mental activity. Intervention in games should be done by managing as little as possible and posing the right question at the right time (stimulating the child's thinking). (Sund, 1976; Wadsworth, 1978; Weikart, et al, 1981; and Kamii & DeVries, 1978). 8) In logical-mathematical knowledge, refrain from telling the right answer and reinforcing it. Reinforcement or verbal correcting of child's knowledge is not desirable because these forms of knowledge are constructions of the child and the child must construct them. The child gets corrective feedback from the manipulation of materials. The teacher is to focus on building confidence, and does not demand right anwers Adult power is reduced as much as possible, but this does not mean a loss of sanctions. Sanctions must be based on positive relationships. Group exclusion is a good measure to use when sanctions are necessary (Kamii, 1973; Becher, 1980; Wadsworth, 1978; and Kamii, & DeVries, 1978). 9) It may be appropriate to teach some information directly and reinforce the learning. For example, immediate feedback is very useful in memorizing time-tables (Wadsworth, 1978; Kamii, 1973).

Operationalization of a Behavioristic Approach to Learning

In defining and operationalizing the behavioristic approach to learn-

ing, Engelmann-Carnine's Direct Instruction Model was used. The Direct Instruction Model is built on two basic premises: first the environmental events are the main determinants of the rate and quality of a child's learning in the classroom; and second, we can increase the amount of learning by carefully orchestrating the child's interaction with his/her environment (Becker, Engelmann, Carnine, and Rhine, 1981; Macoby & Zellner, 1970). The following points are a summary of the Direct Instruction Model: 1) There is structured use of time (Becker, et al, 1981). 2) The primary goal is to teach skills the child can generalize by using sets of related problems that can be solved by using common strategy (Becker, et al, 1981; and Becker, et al, 1975). 3) Small groups are used (six to nine children). Face to face methods of instruction are used whereby the teacher is close enough to touch each child. (Becker, et al, 1981; and Becker, et al, 1975). 4) Based on the basic principles of behavior, the following techniques are used: prompts (signals are taught to each child), fades, repetition of basic concepts, corrections (individual responses), discrimination training, chaining verbal responses, procedures for eliciting and maintaining students' attention, securing responses, giving reinforcements, etc., regulation of verbal behavior of teachers and students, monitoring students' progress, use of praise and other reinforcers to encourage desirable behaviors, use of rapid, high rate oral responding from each child, and the use of step by step chaining in instruction (carefully sequenced lessons).

(Becker, et al, 1981; and Becker, et al, 1975). 5) Teachers are provided with well-planned educational procedures. The components of any lesson plan are: demonstrate operation and repeat, invite the child to join you, remind about rules, use clapping and voice to mark end, use yes-no questions, use action tasks -- clapping, discrimination tasks, and have the children take turns trying (Bereiter & Engelmann, 1966). 8) Use take-home sheets and workbooks. Also use continuous progress tests (Becker, et al, 1975). 9) As the child's learning is advanced, changes and adaptations are made from overtized to covertized problem-solving strategies, from simplified to complex contexts, from providing immediate to delayed feedback, from emphasis on teacher's role as source of information to an emphasis on learner's role as source of information (Rhine, 1981).

In an attempt to directly compare operationalizations of Piagetian learning theory and behavioristic learning theory in an experimental design, the following hypotheses were formed: 1) The Piagetian and behavioristic methods will be equally effective in teaching kindergarten children how to add. 2) The Piagetian method will be more effective than the behavioristic method in regard to transfer or generalization of mathematical concepts from teaching addition to being able to subtract, with kindergarten children (Scandura, 1967; and Rhine, 1981). 3) Neither the Piagetian nor the behavioristic methods of teaching will

adversely effect the self-concepts of the children involved in the learning groups (Rhine, 1981; and Kamii & DeVries, 1978).

Method

Subjects and Procedure.

Subjects were 35 of the 38 5-6½ year old, pre-grade one children living in a small Northern California Community. The selection criteria was that they have no previous training in addition or subtraction, as reported by their parents and teachers. Assignment to group was by random selection, stratified by general academic ability, kindergarten attendance vs home, and by which of the two community schools they were attending. These groups were: the Piagetian method group with eleven Ss (6 boys, 5 girls), the behavioristic method group with twelve Ss (7 boys, 5 girls), and the quasi-control group (6 boys, 6 girls). Elimination of two of the children from the study became necessary at the end of the project when the experimentors learned that one of the girls in the control group had been taught to add, and one of the girls in the Piagetian group refused to answer the post-test questions.

Each of the two experimental groups met with their respective teachers, both female, for 24 days (3 days a week for 8 weeks) for 45 minutes each day in one of the local elementary schools. During this time, each group was taught to add according to operationalizations of the learning theory to which it was assigned. The members of the quasi-control group remained in their usual school or home activities, which allowed chance

to dictate whether members of this group were exposed to any form of mathematical concepts.

Lessons 22 through to 61 were covered in Distar, Arithmetic 1, second ediction, in the behavioristic group, (Engelmann, and Carnine, 1975). Beyond lesson 61, the teacher covered the lessons that related to a basic knowledge of addition and excluded all lessons on subtraction and algebra, up to lesson 72. The specific procedures followed in the Piagetian curriculum made available to the children all the prerequisite skills necessary for addition readiness as specified by Piaget (1941), Wadsworth (1978), Lavatelli (1970), and Kamii and Radin (1970).

The two teachers had a similar amount of teaching experience and identified with their teaching approaches. These teachers were specially trained to use the two different methods for months before the start of the experiment. The behavioristic teacher was trained to use the Distar methods at an Engelmann-Carnine seminar. The Piagetian teacher observed and interacted with a Piagetian-based elementary school in Pasadena, California, and was directly trained in Piagetian methods by the senior author.

Immediately following the 24 days of teaching, the children were randomly assigned to one of the two post test groups. Two female psychology students administered the tests, each one testing one child at a time using separate rooms in the local elementary school. Testing

consisted of orally presenting five addition word problems followed by five subtraction word problems. The Smile Test, a descriptive self concept scale was administered before the word problems (Siperko, 1976).

Results

The analysis of variance of addition scores showed no significant difference among the three groups. The analysis of variance of the subtraction scores showed that a significant difference existed among the three groups $F\ (2,33)=5.865, p<.01$.[1] The follow-up analyses of variance showed the scores of the behavior group to be significantly better than those of-the Piagetian group, $F\ (1,33) = 8.695$, $p<.01$. and of the control group, $F\ (1,33) = 8.05$, $p<.01$. There was no significant difference between the Piagetian subtraction scores and those of the control group.

Insert figure 1 about here

The analysis of variance of scores on the self-concept scales demonstrated no significant differences among the three groups. A comparison of the group mean scores to the standardized mean score of 47.9, showed that all three groups scored above the standardized mean score (scores of 50.6, 50.4, and 50.5).

Discussion and Conclusions

This study demonstrates that the Piagetian and behavioristic theories of learning can be operationalized sufficiently to be compared under experimental-laboratory conditions. However, this examination of the

comparative effectiveness of operationalizations of these two learning theories into teaching methods has shown that both methods were statistically ineffective in teaching pre-school children how to add. This is a surprising finding for it was hypothesized that the two teaching methods would prove to be equally effective, when compated to a quasi-control group. Further research needs to be done using larger samples and having the children exposed to the experimental treatment for a longer time.

Maccoby and Zellenr (1970), Rhine (1981), and Scandura (1967 and 1976) have stated that generalization of concepts will be facilitated by the Piagetian methods. Some behaviorists (Becker, et al, 1981) also hold that their methods of teaching have success in transfer of cognitive concepts because their primary goal is to teach skills that can be generalized. This is done by using sets of related problems that can be solved using a common strategy and teaching of linear-additive sets. Hypothesis 2 was developed on the basis of these contradictory expectations and the assumption that the Piagetian constructivism would be more conducive to generalization. A significant and surprising result was the refutation of hyposthesis 2. The behavioristic group alone exhibited the ability to transfer its base of knowledge to the new task of subtraction. This finding supports Becker's et al (1981) work and refutes the Piagetians' assertions. The explanation of this finding can be seen in the specific techniques, objectives and methods of the

behavioristic approach of Engelmann and Carnine (1975).

Since the Piagetian method is much less direct and structured, it may be that given a longer exposure to the educational treatment, the children could acquire a firm enough understanding of the number concepts being taught to compare favorably with the behavioristic group. The Direct Instruction method is based on the belief that children can be taught specific competencies more quickly because sequential procedures are provided and used in small groups with face-to-face instruction (Becker, et al, 1981; and Gates, 1978). In fact, even Piagetian educators and researchers (Weikart, et al, 1981) have cautioned that some children "acquire' academic skills at a comparatively slow rate" and that their teachers need to be aware of these individual differences. While this time factor may partially explain the superior results from the behavioristic method, further research beyond this pilot study is necessary before this evidence may be accepted as fact. It is also possible that in the Piagetian method, the role of teacher as facilitator of children's growth was a much more difficult role and required more time to learn than did the more highly structured Direct Instruction method (Rhine, 1981).

Gates (1980) has summarized the impression among Piagetians that behaviorists are concerned with efficiency (getting the job done quickly), and not with how the subject feels about their learning experiences or how much personal meaning is involved. However, since both teaching methods were expected to produce effective learning experiences, it was also hypothesized that neither of these learning experiences would be

detrimental to the children involved (Rhine, 1981). It was found that all three groups in the project scored above the standardized mean for the Smile Test, and that the group means were very similar. This suggests that there were no detrimental effects in any of the three experiences (including the behavioristic method) that would influence the child's concept of himself.

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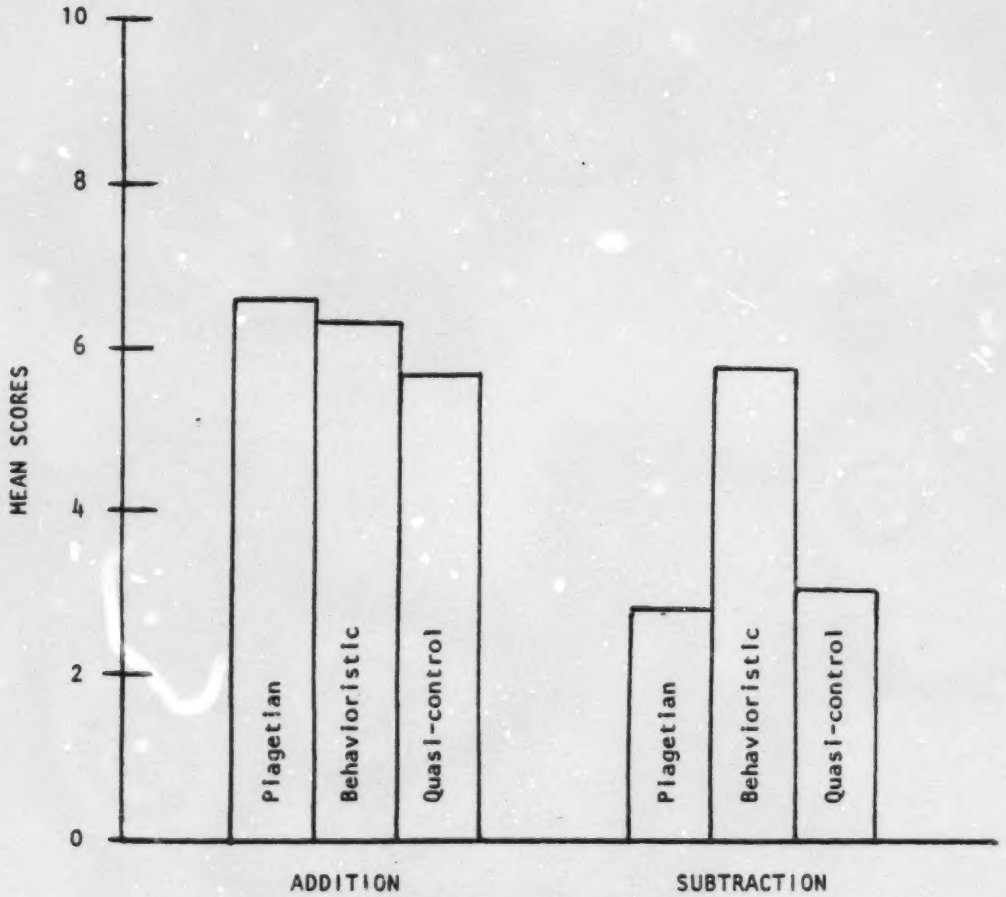
Footnotes

[1]An estimation of missing scores method of cell equalization was used, based on Linton, M. and P.S. Gallo, Jr., The Practical Statistician: Simplified Handbook of Statistics, Monterey, CA.: Brooks/Cole Publishing Co., 1975.

Figure Caption

Figure 1. Mean scores on arithmetic problems.


10
8
6
4
2
0
MEAN SCORES
Piagetian
Behavioristic
Quasi-control
Piagetian
Behavioristic
Quasi-control
ADDITION
SUBTRACTION